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(54) Method and device for controlling combustors for gas-turbine.

(57) A method for controlling a plurality of combustors supplying pressurized gas to a gas turbine, each of which combustors includes a first air supply for supplying combustion air into the combustors, and a second air supply for adjusting the amount of air supplied into the combustor to change a combustion condition in the combustor, which comprises the steps of : measuring the combustion condition of each of the combustors, measuring the difference between the measured combustion condition of each of the combustors and a desired combustion condition, and changing the rate of air supplied into the combustor by the second air supply in each of the combusors according to the measured differences of each of the combustors, to change the combustion condition of each of the combustors to the desired combustion condition.

FIG. 1

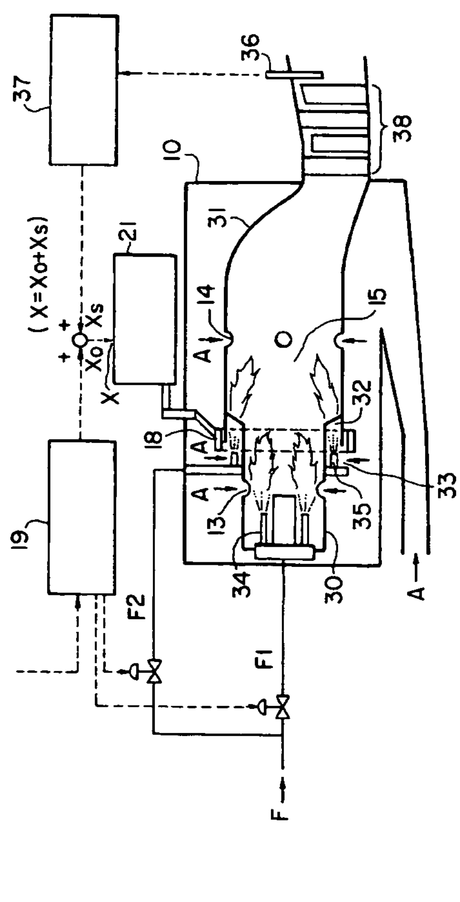

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FIG. 6B

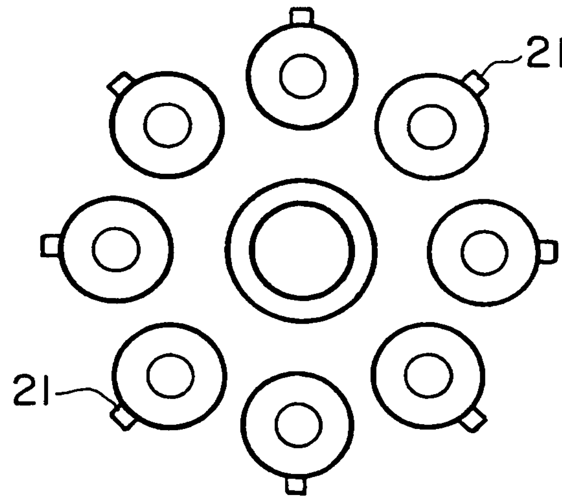
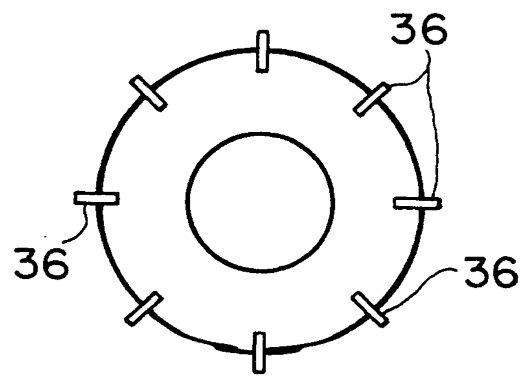


FIG. 6C



BACKGROUND OF THE INVENTION AND RELATED ART STATEMENT

The present invention relates to a method and device for controlling a plurality of combustors supplying a pressurized gas to a gas turbine.

In a conventional device for controlling a plurality of combustors supplying a pressurized gas to a gas turbine as shown in Figs. 3, 4A and 4B, an air A form a compressor (not shown) is supplied into a combustor 115 through a casing 110, diffusion combustion air supply orifices 113 of a diffusion combustion chamber 130, air supply orifices 114 of a pre-mix combustion chamber 131 and pre-mix combustion air supply orifices 133 of a pre-mixing swirler 132. A diffusion combustion fuel F1 is injected from diffusion combustion nozzles 134 into the diffusion combustion chamber 130, a pre-mix combustion fuel F2 is injected from pre-mix combustion nozzles 135 into the pre-mixing swirler 132. An air heated by a fuel combustion to be pressurized is supplied from the combustor 115 to a gas turbine 138 to rotate the gas turbine 138. An open area of the pre-mix combustion air supply orifices 133 is changed by a valve 118 driven by a driver 121. A controller 119 controls a supplying rate of the diffusion combustion fuel F1 according to a load of the gas turbine 138 on a basis of a predetermined relation between the supplying rate of the diffusion combustion fuel F1 and the load of the gas turbine 138 as shown by a solid line in Fig. 4A, and controls a supplying rate of the pre-mix combustion fuel F2 according to the load of the gas turbine 138 on the basis of a predetermined relation between the supplying rate of the pre-mix combustion fuel F2 and the load of the gas turbine 138 as shown by a broken line in Fig. 4A. Further, the controller 119 controls the open area of the pre-mix combustion air supply orifices 133 with the valve 118 driven by the driver 121 according to the load of the gas turbine 138 on the basis of a predetermined common relation between the open area of the pre-mix combustion air supply orifices 133 and the load of the gas turbine 138 as shown in Fig. 4B.

Publication of Japanese Patent Unexamined Publication No. 61-210233 discloses a structure in which a fuel supply rate for each of the combustion chambers is controlled according to a difference between a temperature of a turbine exhaust gas from the each of the combustion chambers and an average value of the turbine exhaust gas temperatures from all of the combustion chambers so that the turbine exhaust gas temperatures from all of the combustion chambers are substantially equal to each other.

Publication of Japanese Patent Unexamined Publication No. 1-150715 discloses a structure in which both of a flow rate of a main combustion air for burning a solid fuel and a flow rate of a supplemental combustion air for burning a supplemental fuel are simultaneously increased or decreased according to a density of a component of the turbine exhaust gas.

OBJECT AND SUMMARY OF THE INVENTION

An object of the present invention is to provide a method and device for controlling a plurality of combustors supplying a pressurized gas to a gas turbine, in which method and device combustion conditions of the combustors can be changed to a desired conbustion condition without a variation of output of the gas turbine.

According to the present invention, a method for controlling a plurality of combustors supplying a pressurized gas to a gas turbine, each of which combustors includes a first air supply means for supplying a combustion air into the combustor and a second air supply means for adjusting an amount of air supplied into the combustor to change a combustion condition in the combustor, comprises the steps of:

measuring the combustion condition of each of the combustors,

measuring a difference between the measured combustion condition of eacah of the combustors and a desired combustion condition, and

changing a rate of the amount of air supplied into the combustor by the second air supply means in relation to an amount of combustion air supplied into the combustor by the first air supply means in each of the combustors according to the measured difference of each of the combustors to change the combustion condition of each of the combustors so that the combustion conditions of the combustors are made substantially equal to each other.

According to the present invention, a device for controlling a plurality of combustors supplying a pressurized gas to a gas turbine, each of which combustors includes a first air supply means for supplying a combustion air into the combustor and a second air supply means for adjusting an amount of air supplied into the combustor to change a combustion condition in the combustor, comprises:

means for measuring the combustion condition of each of the combustors,

means for measuring a difference between the measured combustion condition of each of the combustors and a desired combustion condition, and

means for changing a rate of the amount of air supplied into the combustor by the second air supply means in relation to an amount of combustion air supplied into the combustor by the first air supply means in each of the combustors according to the measured difference of each of the combustors to change the combustion condition of each of the combustors so that the combustion conditions of the combustors are made substantially equal to each other.

Since the rate of the amount of air supplied into the combustor by the second air supply means in relation to the amount of combustion air supplied into the

combustor by the first air supply means in each of the combustors is changed according to the difference between the combustion condition of each of the combustors and the desired combustion condition to change the combustion condition of each of the combustors so that the combustion conditions of the combustors are made substantially equal to each other without changing substantially an amount of fuel supplied to each of the combustors to change the combustion condition of each of the combustors, the combustion condition of each of the combustors can be changed to the desired combustion condition without a variation of output of the gas turbine or with keeping the output of the gas turbine constant.

The combustion condition of each of the combustors can be measured from, for example, a condition of the pressurized gas generated in each of the combustors. That is, the combustion condition may be the condition of the pressurized gas.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view showing a structure of the combustor according to the present invention.

Fig. 2A is a flow chart showing an embodiment of changing the amount of air supplied into the combustor according to the present invention.

Fig. 2B is a flow chart showing another embodiment of changing the amount of air supplied into the combustor according to the present invention.

Fig. 3 is a schematic view showing a structure of a conventional combustor for supplying a pressurized gas to a gas turbine.

Fig. 4A is a diagram showing a predetermined relation between a turbine load and a fuel supply rate in the conventional combustor.

Fig. 4B is a diagram showing a predetermined relation between a turbine load and a valve opening degree for supplying an air into the conventional combustor.

Fig. 5 is a schematic view showing another structure of the combustor according to the present invention.

Figs. 6A, 6B and 6C are schematic views showing an arrangement of the combustors and sensors for measuring the combustion condition of each of the combustors or the condition of the pressurized gas generated by each of the combustors.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As shown in Fig. 1, one of combustors for supplying a pressurized gas to a gas turbine includes a first combustion part into which an air and a fuel are supplied directly and separately to form a diffusion combustion and a second combustion part into which a mixture of the air and fuel mixed previously with each other is supplied to form a premixed combustion. The premixed combustion is efective for decreasing a density of NOx component of a gas discharged from the combustor. An air A is supplied to a combustor casing 10 by a compressor (not shown) and is fed into a combustion chamber 15 through orifices 13 on a diffusion combustion liner 30, an orifice 33 on a premixed combustion liner 31 and orifices 14 on a premixed combustion swirler 32. A diffusion combustion fuel F1 is injected into the combustion chamber 15 by fuel nozzles 34 to form the diffusion combustion. A premixed combustion fuel F2 is injected into the premixed combustion swirler 32 by fuel nozzles 35 to be mixed with the air therein to form the mixture of the air and fuel with an appropriate mixing rate therebetween before the mixture flows into the combustion chamber 15 to be burned therein. A pressurized gas generated from the diffusion combustion and the premixed combustion is mixed with the air supplied from the orifices 14 and the mixed pressurized gas flows to a gas turbine 38.

A valve 18 adjusts or changes a rate of an amount or flow rate of air supplied into the second combustion part of the premixed combustion in relation to an amount or flow rate of air supplied into the first combustion part of the diffusion combustion in each of the combustion chambers 15. In a controller 19, a basic opening degree Xo of the valve 18 as shown in Figs. 2A and 2B is determined according to a desired output of the gas turbine 38 or a needed operation thereof on the basis of a predetermined relation between the basic opening degree Xo and the desired output or needed operation of the gas turbine 38 so that the basic opening degree Xo is output to a driver 21. An output of each of sensors 36 for measuring a combustion condition of each of the combustion chambers 15 or a condition of the pressurized or exhaust gas generated by each of the combustion chambers 15 is transmitted to a valve opening degree determining device 37. Each of the sensors 36 measures, for example, a temperature of the exhaust gas or a density of a component of the exhoust gas. As shown in Fig. 6A, 6B and 6C, a number of the sensors 36 is equal to that of the combustion chambers 15 and the sensors 36 are arranged arround the gas turbine 38 at the outside thereof with a constant circumferential distance between the sensors 36 adjacent to each other. Since a flow of the pressurized gas from each of the combustion chambers 15 is twisted around the gas turbine 38 by a rotation thereof, the condition of the pressurized gas from each one of the combustion chambers 15 is measured by respective one of the sensors at a circumferentially separate position from the each one of the combustion chambers 15.

As shown in Fig. 2A, in the valve opening degree determining device 37, a difference between a temperature Tg measured by each of the sensors 36 and a desired temperature Tgm is calculated. The desired

temperature may be the most appropriate temperature which is previously determined or is calculated from the other operational conditions, an average temperature of all of the measured temperatures Tg, an average temperature of the measured temperatures Tg other than the measured temperature Tg on which the difference is being calculated or an average temperature of the measured temperatures Tg of at least two of the combustors. When [(the measured temperature Tg - the desired temperature)/the desired temperature Tgm] is larger than a predetermined degree εl, a conpensation degree Xs is increased from the previously determined conpensation degree Xs by a predetermined degree Δx so that an opening degree X of the valve 18 is adjusted or increased to [the basic opening degree Xo + (the previous conpensation degree Xs + Δx)] to increase an air flow A2 to the premixed combustion part. When [(the desired temperature - the measured temperature Tg)/the desired temperature Tgm] is larger than a predetermined degree $\varepsilon 2$, the conpensation degree Xs is decreased from the previously determined conpensation degree Xs by the predetermined degree Δx so that the opening degree X of the valve 18 is adjusted or decreased to [the basic opening degree xo + (the previous conpensation degree Xs - Δx)] to decrease the air flow A2 to the premixed combustion part.

Alternatively, when (the measured temperature Tg - the desired temperature) is larger than the predetermined degree $\varepsilon 1$, the conpensation degree Xs is increased from the previously determined conpensation degree Xs by the predetermined degree Δx so that the opening degree X of the valve 18 is adjusted or increased to [the basic opening degree Xo + (the previous conpensation degree Xs + Δx)] to increase the air flow A2 to the premixed combustion part. When (the desired temperature - the measured temperature Tg) is larger than the predetermined degree $\varepsilon 2$, the conpensation degree Xs is decreased from the previously determined conpensation degree Xs by the predetermined degree Δx so that the opening degree X of the valve 18 is adjusted or decreased to [the basic opening degree Xo + (the previous conpensation degree Xs - Δx)] to decrease the air flow A2 to the premixed combustion part. The degree Δx may be in proportion to the difference between the temperature Tg measured by each of the sensors 36 and the desired temperature Tgm. This operation is carried out for each of the combustors or combustion chambers 15 in order. A set of these ordered operations for the combustors or combustion chambers 15 is carried out with a constant interval τ from the previous set, for example, with the interval of ten seconds. As a result of the above operations, the temperatures of the pressurized gas from the combustors or combustion chambers 15 are made substantially equal to each other or changed to the desired temperature.

The sensors 36 may measure a density of NOx and/or CO and/or hydro-carbon of the pressurized gas. As shown in Fig. 2B, a difference between a NOx density measured by each of the sensors 36 and a desired NOx density is calculated, and a fifference between a CO density measured by each of the sensors 36 and a desired CO density is calculated. The desired densities of NOx and CO are predetermined. When (the measured NOx density - the desired NOx density) is larger than a predetermined degree $\varepsilon 3$, the conpensation degree Xs is increased from the previously determined conpensation degree Xs by the predetermined degree Δx so that the opening degree X of the valve 18 is adjusted or increased to [the basic opening degree Xo + (the previous conpensation degree Xs + Δx)] to increase the air flow A2 to the premixed combustion part. When (the measured CO density - the desired CO density) is larger than a predetermined degree $\varepsilon 4$, the conpensation degree Xs is decreased from the previously determined conpensation degree Xs by the predetermined degree Δx so that the opening degree X of the valve 18 is adjusted or decreased to [the basic opening degree Xo + (the previous conpensation degree Xs - Δx)] to decrease the air flow A2 to the premixed combustion part. The degree Δx may be in proportion to the difference between the density measured by each of the sensors 36 and the desired density.

In an embodiment as shown in Fig. 5, each of the combustors or combustion chambers 15 includes a diffusion combustion part and does not include a premixed combustion part. The valve 18 is arranged at a downstream side of the diffusion combusion part to change a flow rate of air supplied into the combustion chamber 15 or added to the pressurized gas generated by the diffusion combusion part, through the orifices 14. The air A from the compressor (not shown) is supplied into the casing 10. Subsequently, an air A1 flows into the combustion chamber 15 through orifices 43 and the orifices 13 on the combustion liner30 and an air A2 flows into the combustion chamber 15 through the orifices 14 on the combustion liner 30. The fuel F is injected from the nozzle 34 into the combustion chamber 15 to form the diffusion combustion with the air. When the fuel is a combustible gas made from coal and includes large percents of nitrogen atoms, it is effective for decreasing a density of NOx in the pressurized gas from the combustion chamber 15 that the diffusion combustion is carried out with an insufficient flow rate of the air A1 supplied into the combustion chamber 15 through the orifices 43 and 13 in relation to a flow rate of the fuel F supplied into the combustion chamber 15 through the nozzle 34 so that the fuel F is not completely burned up by the air A1 to change the nitrogen atoms to nitrogen molecules (N_2) and subsequently a part of the fuel F which was not burned up by the diffusion combustion is burned up by the air A2.

In order to obtain the above operation for dec-

reasing the density of NOx in the pressurized gas, that is, to obtain so called a rich-lean combustion, the opening degree X of the valve 18 is increased to increase the air flow A2 when a NOx density measured by each of the sensors 36 is larger than a predetermined desired NOx density, and the opening degree X of the valve 18 is decreased to decrease the air flow A2 when a density of the part of the fuel F which was not burned up by the diffusion combustion is larger than a predetermined desired density thereof.

Claims

1. A method for controlling a plurality of. combustors supplying a pressurized gas to a gas turbine, each of which combustors includes a first air supply means for supplying a combustion air into the combustor and a second air supply means for adjusting an amount of air supplied into the combustor to change a combustion condition in the combustor, comprises the steps of:
   measuring the combustion condition of each of the combustors,
   measuring a difference between the measured combustion condition of each of the combustors and a desired combustion condition, and
   changing a rate of the amount of air supplied into the combustor by the second air supply means in relation to an amount of combustion air supplied into the combustor by the first air supply means in each of the combustors according to the measured difference of each of the combustors to change the combustion condition of each of the combustors so that the combustion conditions of the combustors are changed to the desired combustion condition.

2. A method according to claim 1, wherein a temperature of the pressurized gas is measured as the measured combustion condition, and the desired combustion condition is a desired temperature of the pressurized gas.

3. A method according to claim 1, wherein a density of a component of the pressurized gas is measured as the measured combustion condition, and the desired combustion condition is a desired density of the component of the pressurized gas.

4. A method according to claim 1, wherein the desired combustion condition is an average combustion condition of the measured combustion conditions of at least two of the combustors.

5. A method according to claim 1, wherein the desired combustion condition is the most appropriate combustion condition of the combustor.

6. A method according to claim 1, wherein the first air supply means supplies the combustion air for a diffusion combustion, and the second air supply means supplies the combustion air for a premixed combustion.

7. A method according to claim 1, wherein the first air supply means supplies the combustion air for a diffusion combustion, and the second air supply means supplies an additional air to be added into the pressurized gas generated by the diffusion combustion.

8. A method according to claim 1, wherein in each of the combustors, the rate of the amount of air supplied into the combustor by the second air supply means in relation to the amount of combustion air supplied into the combustor by the first air supply means is changed by a degree which is in proportion to the measured difference of each of the combustors.

9. A method according to claim 1, wherein in each of the combustors, the rate of the amount of air supplied into the combustor by the second air supply means in relation to the amount of combustion air supplied into the combustor by the first air supply means continues to be changed by a predetermined constant degree.

10. A method according to claim 2, wherein in each of the combustors, the rate of the amount of air supplied into the combustor by the second air supply means in relation to the amount of combustion air supplied into the combustor by the first air supply means is increased when the measured temperature of the pressurized gas is higher than the desired temperature of the pressurized gas, and the rate of the amount of air supplied into the combustor by the second air supply means in relation to the amount of combustion air supplied into the combustor by the first air supply means is decreased when the measured temperature of the pressurized gas is lower than the desired temperature of the pressurized gas.

11. A method according to claim 3, wherein a density of NOx (nitrogen oxide) component of the pressurized gas is measured as the measured combustion conditin, the desired combustion condition is a desired density of NOx component of the pressurized gas, and in each of the combustors, the rate of the amount of air supplied into the combustor by the second air supply means in

relation to the amount of combustion air supplied into the combustor by the first air supply means is increased when the measured NOx density of the pressurized gas is higher than the desired NOx density of the pressurized gas.

12. A method according to claim 3, wherein a density of CO (carbon monoxide) component of the pressurized gas is measured as the measured combustion condition, the desired combustion condition is a desired density of CO component of the pressurized gas, and in each of the combustors, the rate of the amount of air supplied into the combustor by the second air supply means in relation to the amount of combustion air supplied into the combustor by the first air supply means is decreased when the measured CO density of the pressurized gas is higher than the desired CO density of the pressurized gas.

13. A method according to claim 4, wherein the desired combustion condition is an average combustion conditin of the measured combustion conditions of all of the combustors.

14. A method according to claim 4, wherein the desired combustion condition is an average combustion condition of the measured combustion conditions of at least two of the combustors other than the combustor where the difference is being measured.

15. A device for controlling a plurality of combustors supplying a pressurized gas to a gas turbine, each of which combustors includes a first air supply means for supplying a combustion air into the combustor and a second air supply means for adjusting an amount of air supplied into the combustor to change a combustion condition in the combustor, comprises:

means for measuring the combustion condition of each of the combustors,

means for measuring a difference between the measured combustion condition of each of the combustors and a desired combustion condition, and

means for changing a rate of the amount of air supplied into the combustor by the second air supply means in relation to an amount of combustion air supplied into the combustor by the first air supply means in each of the combustors according to the measured difference of each of the combustors to change the combustion condition of each of the combustors so taht the combustion conditions of the combustors are changed to the desired combustion condition.

16. A device according to claim 15, wherein the first air supply means supplies the combustion air for a diffusion combustion, and the second air supply means supplies the combustion air for a premixed combustion.

17. A device according to claim 15, wherein the first air supply means supplies the combustion air for a diffusion combustion, and the second air supply means supplies an additional air to be added into the pressurized gas generated by the diffusion combustion.

18. A device according to claim 15, wherein the means for measuring the combustion condition measures a temperature of the pressurized gas.

19. A device according to claim 15, wherein the means for measuring the combustion condition measures a density of a component of the pressurized gas.

20. A device according to claim 15, wherein the desired combustion condition is an average combustion condition of the measured combustion conditions of at least two of the combustors.

FIG. 1

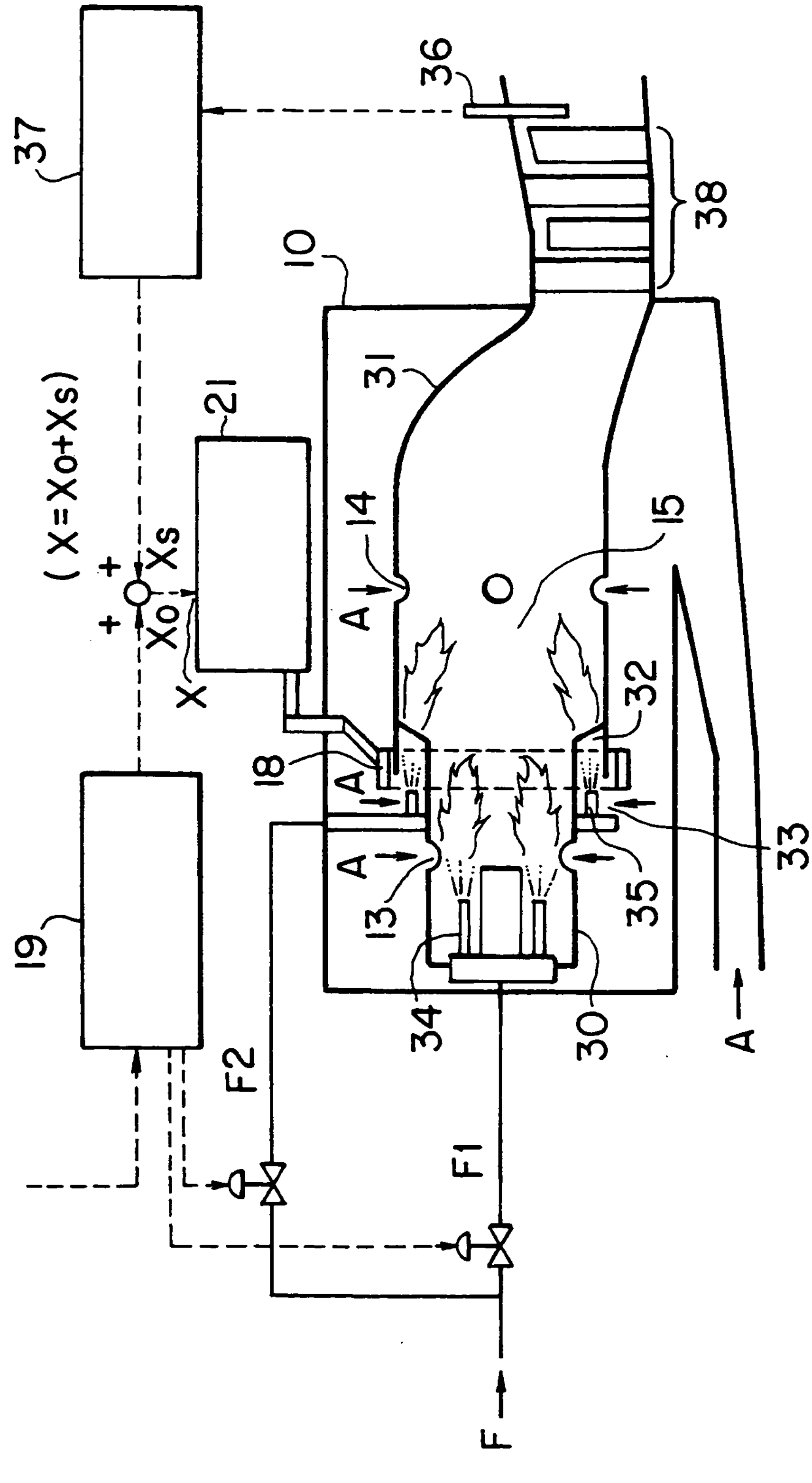


FIG. 2A

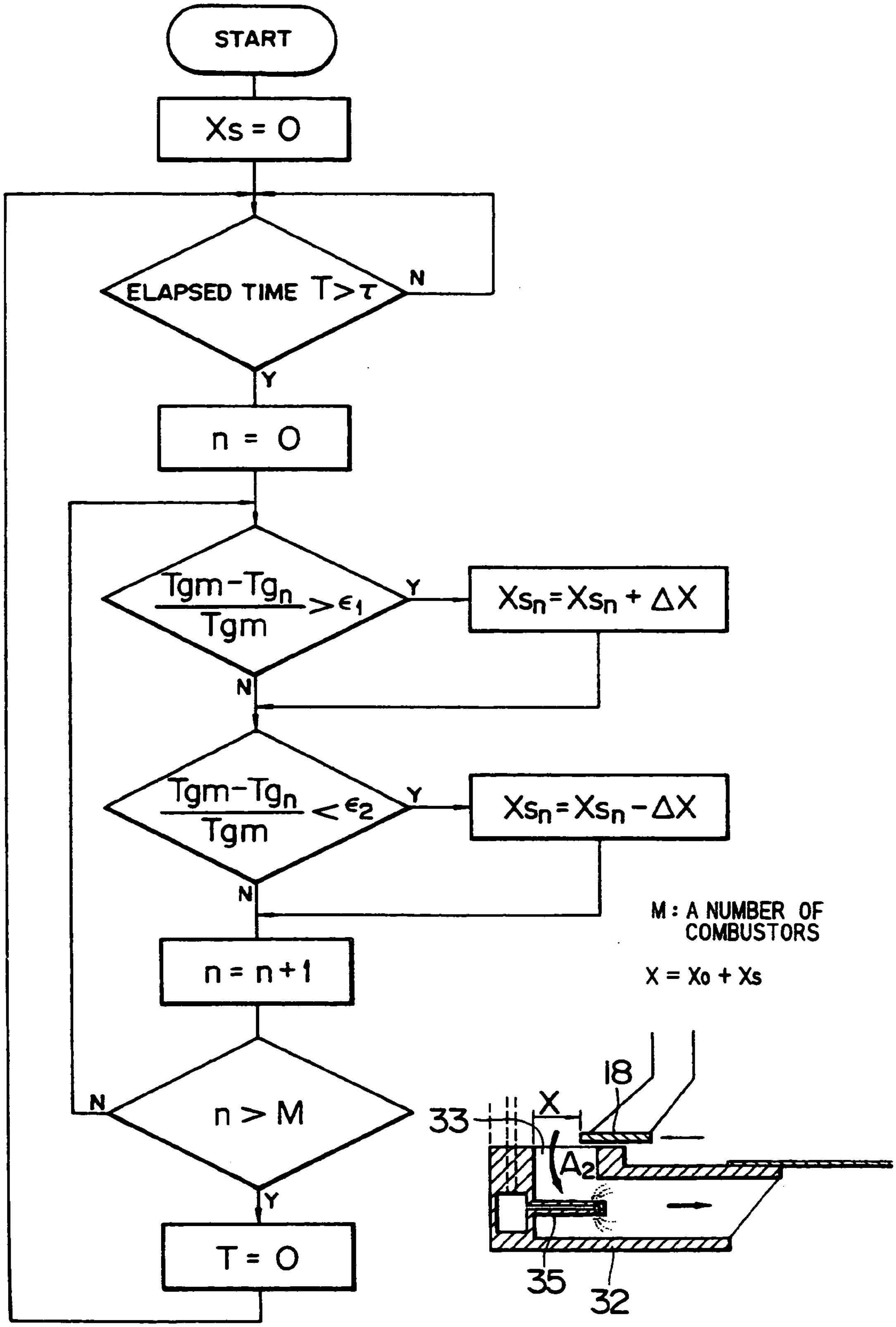
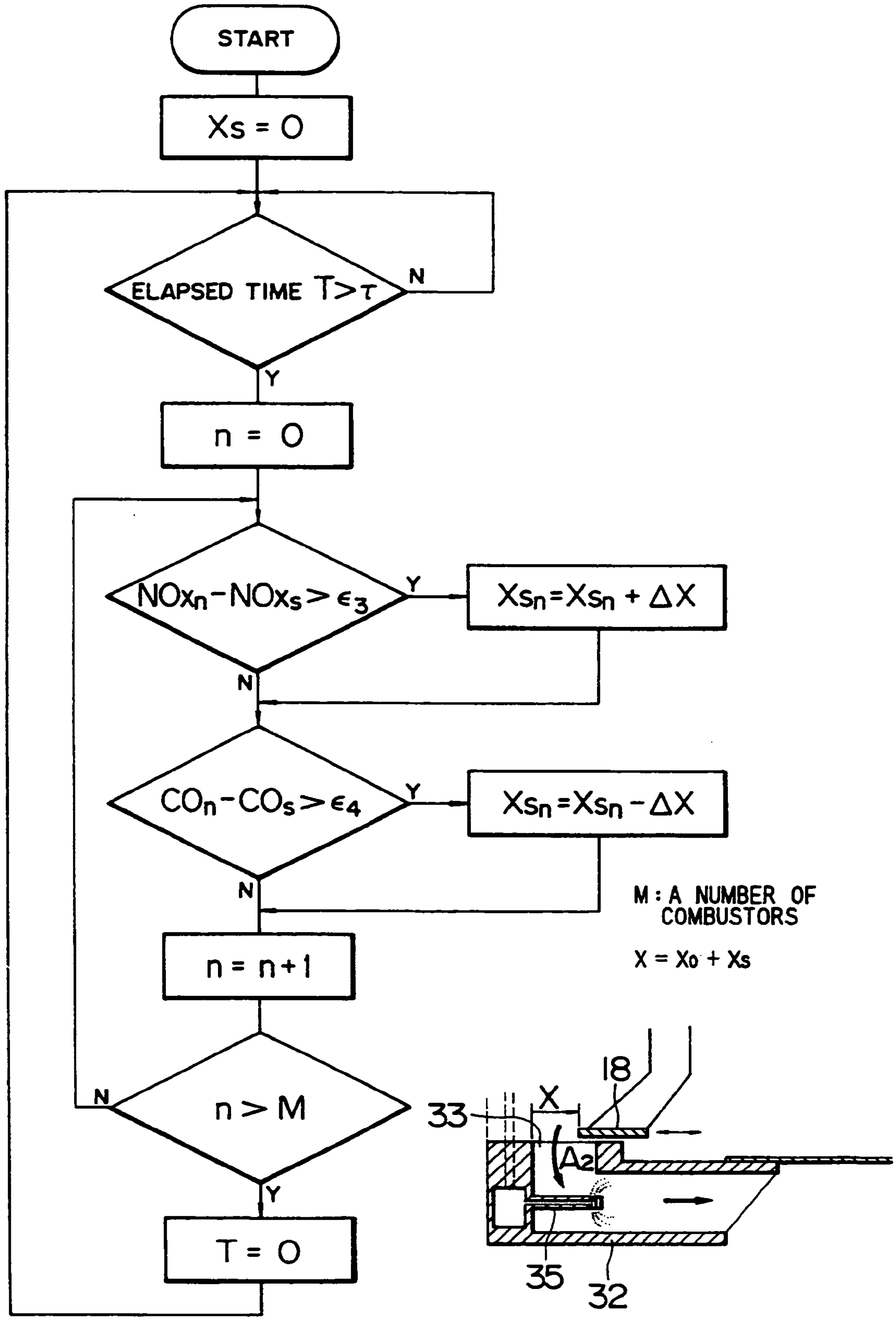

START
Xs = O
ELAPSED TIME T > τ
N
Y
n = O
(Tgm − Tgn) / Tgm > ε1
Y
Xsn = Xsn + ΔX
N
(Tgm − Tgn) / Tgm < ε2
Y
Xsn = Xsn − ΔX
N
n = n + 1
n > M
N
Y
T = O
M : A NUMBER OF COMBUSTORS
X = Xo + Xs
18
33
X
A2
35
32

FIG. 2B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Xs = 0
ELAPSED TIME T>τ
N
Y
n = 0
NOxn-NOxs>ε3
Y
Xsn=Xsn + ΔX
N
COn-COs>ε4
Y
Xsn=Xsn - ΔX
N
n = n+1
n>M
N
Y
T = 0
M : A NUMBER OF COMBUSTORS
X = Xo + Xs
18
X
33
A2
35
32

FIG. 3
PRIOR ART

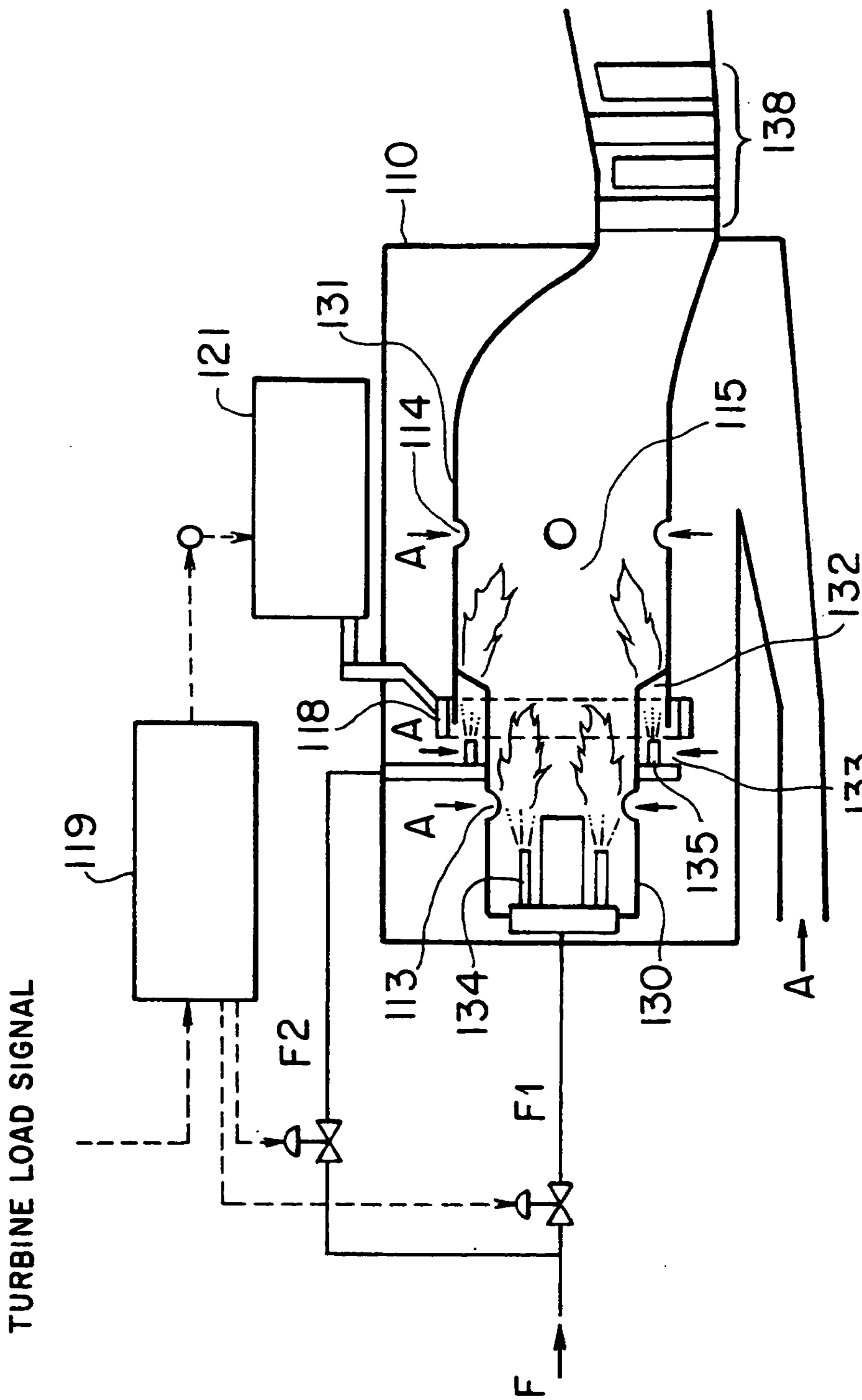


FIG. 4A
PRIOR ART

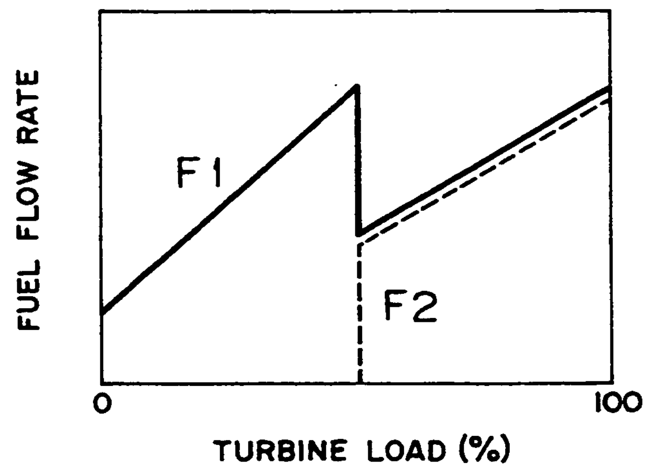


FIG. 4B
PRIOR ART

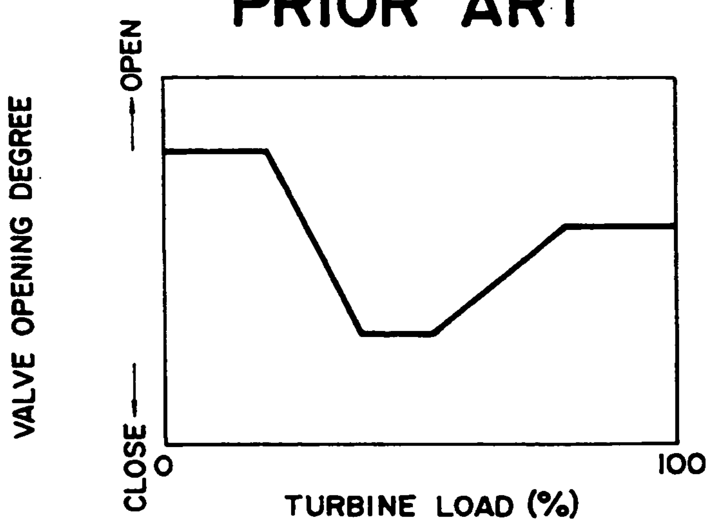


FIG. 5

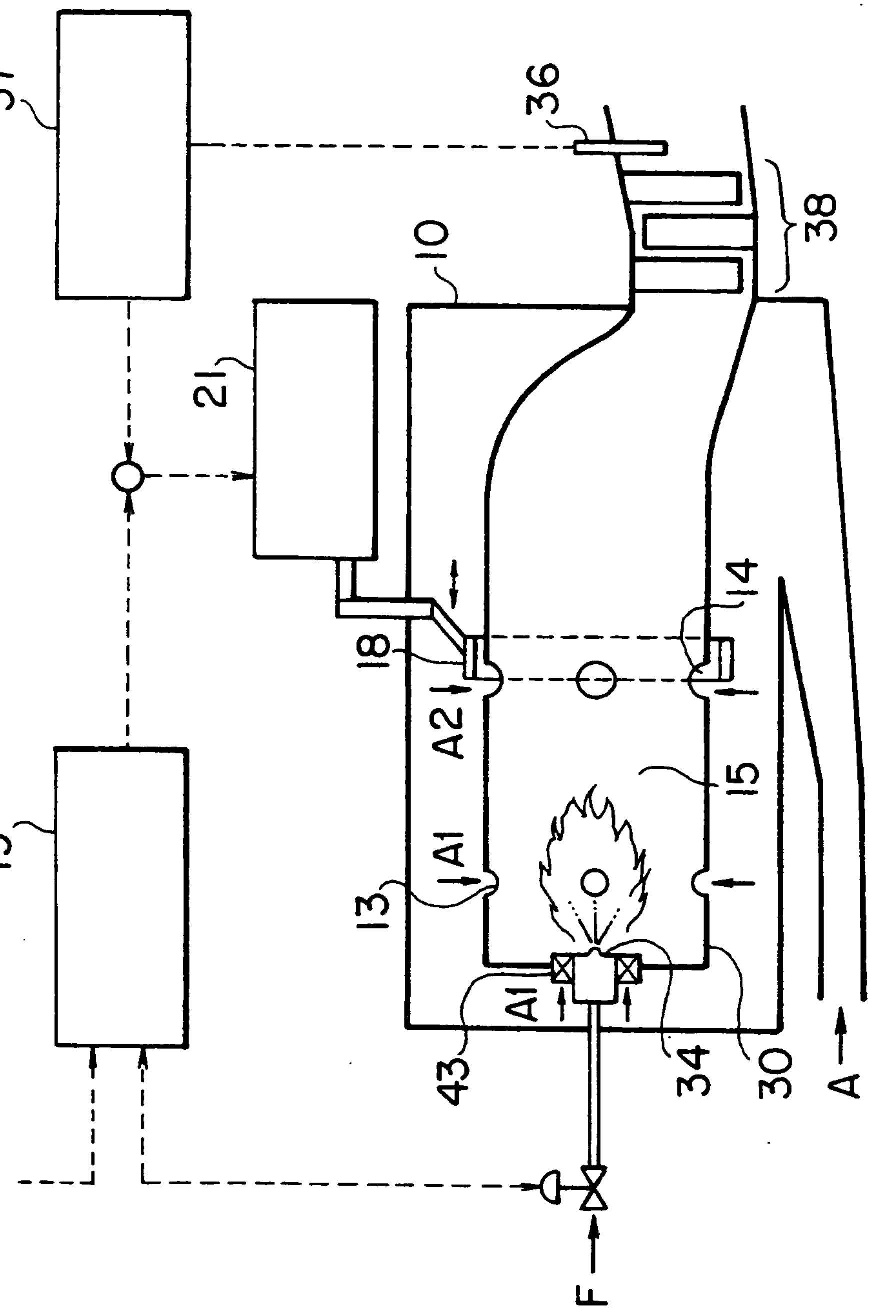


FIG. 6A

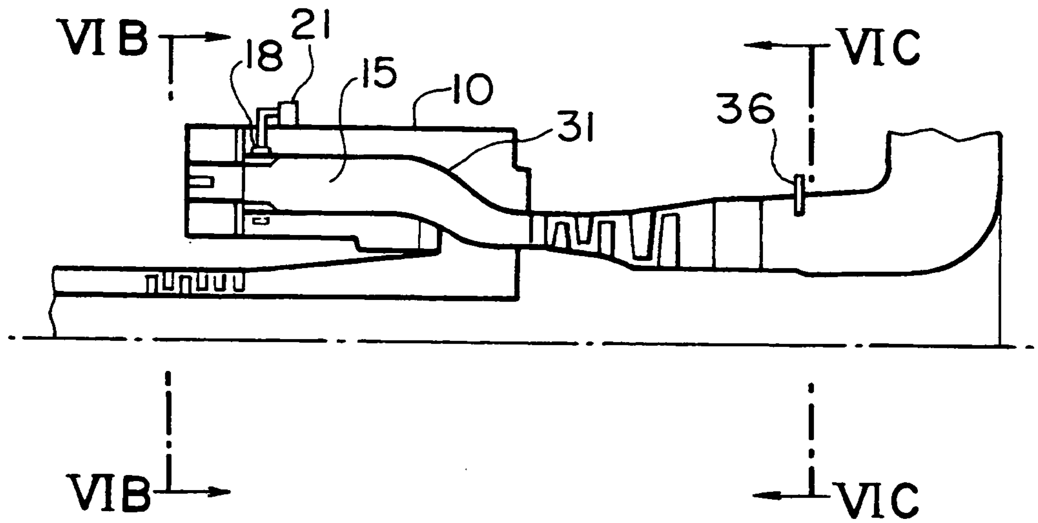


FIG. 6B

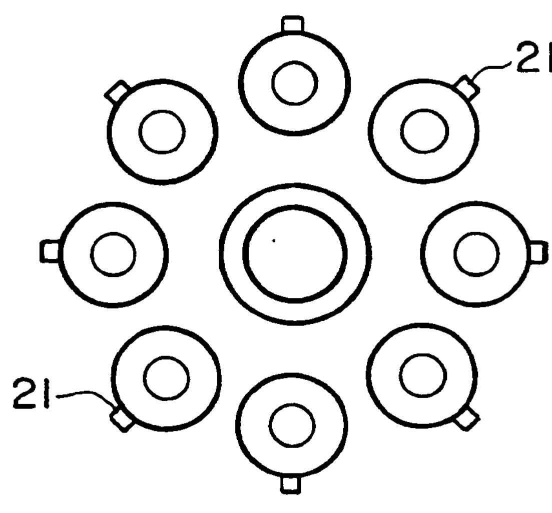
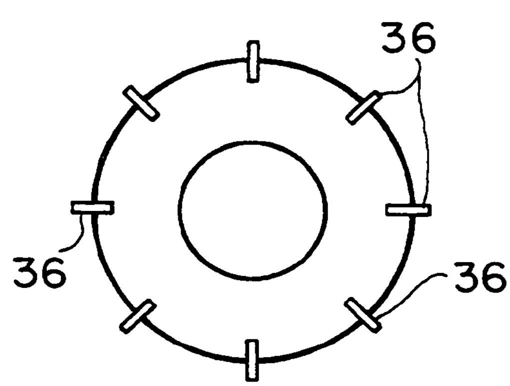


FIG. 6C



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 31 1080

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y,D	PATENT ABSTRACTS OF JAPAN vol. 11, no. 48 (M-561)(2495) 13 February 1987 & JP-61 210 233 (HITACHI LTD.) 18 September 1986 * abstract *	1-20	F23R3/26 F01D17/08
Y,D	PATENT ABSTRACTS OF JAPAN vol. 13, no. 411 (M-869)(3759) 11 September 1989 & JP-1 150 715 (TOSHIBA CORP.) 13 June 1989 * abstract *	1-20	
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 25 (M-190)(1170) 2 February 1983 & JP-57 179 519 (HITACHI) 5 November 1982 * abstract *	1	
A	GB-A-2 226 366 (ROLLS-ROYCE LTD.) * page 2, line 8 - line 28; figures *	1	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F23R
F01D
F02C
F23N
H02H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	05 MARCH 1992	CRIADO Y JIMENEZ, F.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document